MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2018/2019

DET5038 – POWER ELECTRONICS

(Diploma in Electronics Engineering)

30 MAY 2019
9:00 AM –11:00 AM
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **5** pages excluding the cover page and appendix.
2. Answer ALL questions. All necessary working steps must be shown.
3. Write all your answers in the answer booklet provided.

QUESTION 1 [20 marks]

(a) Compare MOSFET and BJT characteristic in terms of:

(i) Trigger method to switch ON the device (2 marks)

(ii) Switching speed (2 marks)

(iii) On state voltage drop (2 marks)

(iv) Blocking voltage (2 marks)

(v) Temperature coefficient of on-state resistance (2 marks)

(b) Figure 1 shows a single phase full wave rectifier circuit with resistive load for both positive and negative cycle of the AC supply voltage. Explain in detail the operation of the circuit base on the notation provided in Figure 1. Sketch the expected waveform for V_S, I_S, V_0, I_0, $I_{D1/D2}$ and $I_{D3/D4}$.

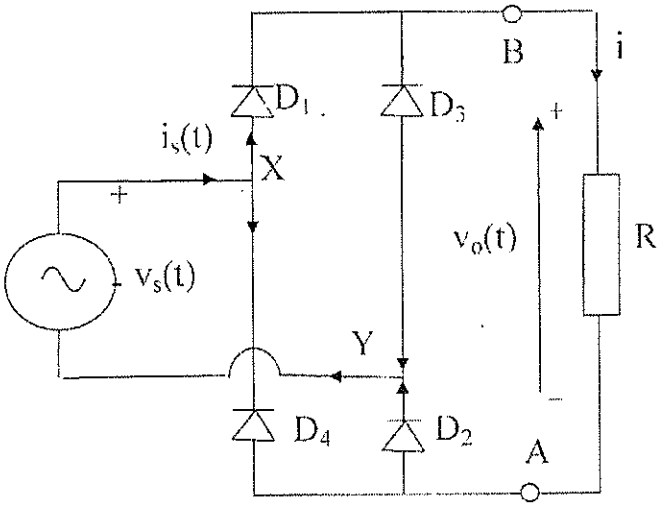


Figure 1

(10 marks)

Continued ...

QUESTION 2 [20 marks]

(a) Draw the schematic diagram of a buck DC-DC converter, a boost DC-DC converter and a buck-boost DC-DC converter. Briefly explain the main function for each types of the converters. State which of the converters is most suitable to be apply into an adjustable power supply unit.

(10 marks)

(b) Figure 2 shows a single phase half bridge inverter circuit with resistive and inductive load to convert DC to AC. Explain in detail the operation of the circuit base on the notation provided in Figure 2. Sketch the expected waveform for V_0 and I_0.

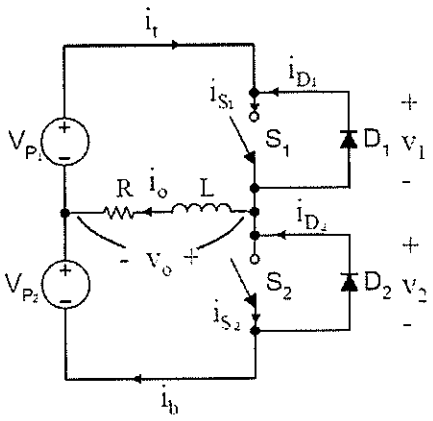


Figure 2

(7 marks)

(c) Figure 3 shows a resonant converter. Sketch the equivalent circuit for all three modes (Mode 1, Mode 2 and Mode 3) of the circuit's operation.

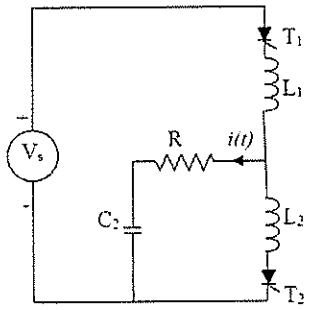


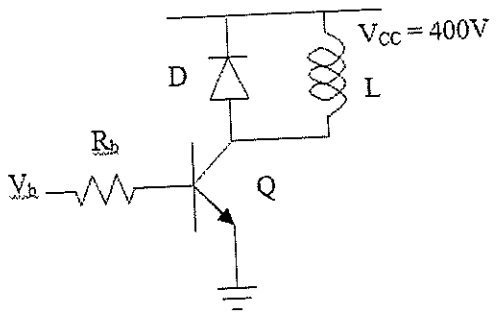
Figure 3

(3 marks)

Continued ...

QUESTION 3 [20 marks]

A power BJT is used to switch an inductive load across a 400 V supply at 10000 Hz, as shown in Figure 4. The transistor is in the on-state and off-state for the same length of duration in static state. The inductance of the load is large so that the load current is constant with a value of 10 A.



$V_{CE(sat)} = 0.3$ V

$V_{BE(on)} = 0.7$ V

$I_{C(leak)} = 500$ uA

$\beta = 20$

$\tau_{on} = 1 \ \mu s$

$\tau_{off} = 1 \ \mu s$

Figure 4

By neglecting the on state voltage drop across the diode, calculate the following:

(a) t_{on} and t_{off} (6 marks)

(b) P_{static} (9 marks)

(c) $P_{dynamic}$ (3 marks)

(d) P_{TOTAL} (2 marks)

Continued ...

QUESTION 4 [20 marks]

(a) A half wave diode rectifier has an AC input voltage of 240V with the output terminal connected to 100 Ω resistor. Assume that the diode is ideal. Determine:

(i) The power loss incurred by the diode if the diode has V_{th} = 1.5 V and R_{on} = 0.2 Ω.

(5 marks)

(ii) Average output voltage.

(1 mark)

(iii) RMS output voltage.

(1 mark)

(iv) Ripple voltage.

(2 marks)

(v) Ripple voltage factor.

(1 mark)

(b) A buck-boost converter generates an output voltage of 48 V across a 20 Ω resistor from an input voltage of 12 V. The output ripple voltage must be less than 1 V at a switching frequency of 1500 Hz under continuous conduction mode. Determine the following parameters:

(i) The input and output power.

(4 marks)

(ii) The duty ratio.

(2 marks)

(iii) The inductance value.

(2 marks)

(iv) The capacitance value.

(2 marks)

Continued ...

QUESTION 5 [20 marks]

(a) Calculate the following for the single-phase half-bridge inverter which, has a DC input voltage of $V_S = 220\ V$.

(i) The RMS output voltage of the fundamental component.

(1 mark)

(ii) The RMS output voltage.

(1 mark)

(iii) The RMS output voltage of total harmonic component.

(2 marks)

(iv) The harmonic factor of the 1st, 2nd and 3rd harmonic.

(2 marks)

(v) The total harmonic distortion.

(2 marks)

(vi) The voltage transfer ratio.

(2 marks)

(b) Figure 5 shows a resonant inverter circuit. It is operating at an output frequency of 8 kHz. The circuit turn off time is given as 45 μs.

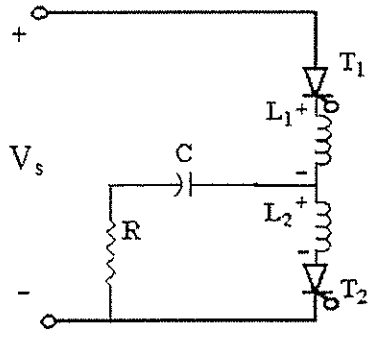


Figure 5

Assume that the circuit turn off time is nine times longer than the thyristor turn off time, determine the maximum permissible frequency, f_{max}.

(10 marks)

End of Page.

APPENDIX

Table 1 Switching power loss of power BJT

	Resistive Load	Inductive Load
ON state	$P_{on} = [V_{CE(sat)} I_{C(on)} + V_{BE(on)} I_{B(on)}] \frac{t_{on}}{T}$	$P_{on} = [V_{CE(sat)} I_{C(on)} + V_{BE(on)} I_{B(on)}] \frac{t_{on}}{T}$
OFF state	$P_{off} = [V_{CC} I_{C(leak)}] \frac{t_{off}}{T}$	$P_{off} = [V_{CC} I_{C(leak)}] \frac{t_{off}}{T}$
Turn On	$P_{turn-on} = V_{CC} I_{C(on)} \frac{\tau_{on}}{6T}$	$P_{turn-on} = V_{CC} I_{C(on)} \frac{\tau_{on}}{2T}$
Turn Off	$P_{turn-off} = V_{CC} I_{C(on)} \frac{\tau_{off}}{6T}$	$P_{turn-off} = V_{CC} I_{C(on)} \frac{\tau_{off}}{2T}$

Table 2 Switching power loss of power MOSFET

	Resistive Load	Inductive Load
ON state	$P_{on} = I^2_{D(on)} R_{DS(on)} \frac{t_{on}}{T}$	$P_{on} = I^2_{D(on)} R_{DS(on)} \frac{t_{on}}{T}$
OFF state	$P_{off} = I_{D(off)} V_{DD} \frac{t_{off}}{T}$	$P_{off} = I_{D(off)} V_{DD} \frac{t_{off}}{T}$
Turn On	$P_{turn-on} = \frac{V_{DD} I_{D(on)} \tau_{on}}{6T}$	$P_{turn-on} = \frac{V_{DD} I_{D(on)} \tau_{on}}{2T}$
Turn Off	$P_{turn-off} = \frac{V_{DD} I_{D(on)} \tau_{off}}{6T}$	$P_{turn-off} = \frac{V_{DD} I_{D(on)} \tau_{off}}{2T}$

Table 3 Useful equations of DC to DC converters

Buck Converter	Boost Converter	Buck-Boost Converter
$V_o = DV_s$	$D = 1 - \frac{V_s}{V_o}$	$D = \frac{V_O}{V_s + V_O}$
$I_L = \frac{V_o}{R}$ $(\Delta i_L)_{close} = \frac{V_s - V_o}{L} DT$ $(\Delta i_L)_{open} = -\frac{V_o}{L}(1-D)T$	$I_L = \frac{V_s}{R(1-D)^2}$ $(\Delta i_L)_{close} = \frac{V_s}{L} DT$ $(\Delta i_L)_{open} = \frac{V_S - V_o}{L}(1-D)T$	$I_L = \frac{V_s D}{R(1-D)^2}$ $(\Delta i_L)_{close} = \frac{V_S}{L} DT$ $(\Delta i_L)_{open} = -\frac{V_o}{L}(1-D)T$
$L = \frac{(1-D)R}{2f}$	$L = \frac{D(1-D)^2 R}{2f}$	$L = \frac{(1-D)^2 R}{2f}$
$C_{min} = \frac{1-D}{8Lf^2 \frac{\Delta V_o}{V_o}}$	$C = \frac{D}{Rf \frac{\Delta V_o}{V_o}}$	$C = \frac{D}{Rf \frac{\Delta V_o}{V_o}}$